and C-340, C-400, C-410, and C-420 could have exposed maintenance mechanics to concentrated inhalation and contamination hazards.

Several formal cascade improvement programs (CIPs) and cascade uprating programs (CUPs) involving replacement of major components to increase diffusion process reliability, capacity, and efficiency started as early as 1954. The second major CIP/CUP started in March 1973 and continued for eight years. This CIP/CUP process involved cell by cell removal of compressors and converters, process piping, and support system components while the remainder of the cascades remained in operation. After removal, compressors and converters were taken to C-400 for disassembly, cleaning, and decontamination and then to C-720, where they were modified and reassembled prior to reinstallation. In addition to releases of UF_6, these disassembly activities exposed maintenance workers to transuranics and fission products adhering to surfaces inside the system and to trichloroethene (TCE) during degreasing and decontamination. Workers could have received significant radiation exposures by inhaling neptunium-237 dust. At the completion of the CIP/CUP activities, converter and compressor disassembly remained a routine operation.

Between March and May of 1977, C-340 underwent a slow and deliberate shutdown for an indefinite period. During the shutdown period, which lasted until the mid-1980s, Building C-340 was used as a valve rebuilding shop and routine maintenance facility.

2.4 Unusual Occurrences and Accidents

During its first 40 years of operation, PGDP experienced numerous operational upsets, releases, exposures, and other accidents. Documentation, investigation, and reporting of these unusual events were very inconsistent and infrequent until the initiation of DOE's formal occurrence reporting systems in the late 1980s. One of the most frequent and notable unusual events was the release of UF_6 gas into work areas or the environment. The releases ranged from very small amounts, commonly referred to as "puffs," to significant amounts that resulted in HF burns, and uranium intakes requiring bioassay or medical attention for dozens of workers. The sources of these releases included the process system during system upgrade work, equipment failures, and maintenance activities; cylinder connection and disconnection activities at feed and withdrawal stations; and process equipment disassembly during shop maintenance activities in C-400 and C-720.

Several evaluation reports on UF_6 releases and their effects, as well as other site documents, identified approximately 50 UF_6 releases, each in excess of 10 pounds of uranium. However, reviews of health physics reports and the site quarterly progress reports from the early 1960s revealed references to many hundreds of releases of varying sizes (described often only as minor, large, or major). These reports identified many employees who were exposed from these releases and required medical examinations and bioassay. Burns and respiratory tract bleeding from exposures to or inhalation of HF were frequent occurrences. Many health physics reports indicated that these releases were not documented in operations shift logs and were often not addressed in the Plant's quarterly progress reports to the AEC, which was the regulatory agency at that time.

At least 15 events were identified in the first ten years of Plant operation that each released a minimum of 100 pounds of uranium, with a 1960 event releasing approximately 6,800 pounds and a 1962 event releasing approximately 3,400 pounds. As better equipment was installed and major system upgrade work ended, operational practices improved and the number and quantity of UF_6 releases decreased significantly. In the 1980s, reported releases were on the order of one to five per month and were measured in grams instead of pounds. The number of persons placed on recall for bioassay decreased from 30 or more per month in the 1950s to one to six per year in the 1980s.

C-337 Fire and Explosion - December 1962

Other significant Plant events included a major fire in Building C-310 in 1956, overexposure of two maintenance mechanics to beta radiation, and an explosion and fire in C-315 in 1978. Major releases affecting groundwater included a spill of 17,000 gallons of diesel oil migrating as far as 2 miles from the site boundary via surface water and the identification of

significant volumes of TCE leakage from C-400 to the site sewer system, discovered in June 1986. Three fatalities were reported as a result of Plant events: an explosion and fire in C-340 in 1962, electrocution of an electrical maintenance trainee in 1977, and the suffocation of an operator in the collapse of a coal bridge at the steam plant in the 1970s. In addition, in June 1958, a release of HF severely burned a worker who did not return to work.

2.5 Industrial Hygiene and Radiation Protection

Programs for industrial hygiene and radiation protection were in existence from the beginning of Plant operation. Initial Plant training classes included theory and protective actions for working with radioactive and hazardous materials. There were policies and procedures that addressed the radiological protection of workers. PPE was provided and available to workers and in work areas where hazards were deemed greatest and protection was deemed necessary. The amount of formal training given to employees diminished after Plant startup, and much of the knowledge concerning both operations and hazard communication and controls resulted from on-the-job training of new workers by more experienced personnel and by supervisors. Starting in the early 1960s, job hazard analyses (JHAs) were prepared for most work activities and addressed many safety hazards, but not all JHAs adequately addressed radiation protection. Safety committees and regularly scheduled safety meetings, which included radiological subjects, were important elements of the process of hazard communication.

Non-radiation hazards, such as industrial and chemical exposures (primarily HF), were evaluated and addressed throughout the history of the Plant. The evolution of awareness and the application of protection and controls for significant hazards, such as asbestos and polychlorinated biphenyls (PCBs), essentially paralleled that of the regulatory bodies and general industry. Air monitoring of hazardous job sites existed from Plant startup, and health physics personnel monitored air and surface contamination in work areas and recommended additional or modifications to engineering controls or PPE, if deemed necessary. As early as 1952, Plant health physics personnel were aware of the potential hazards of personnel contamination and instituted measures such as monitoring work areas, providing company clothing, and providing frisking devices for workers to monitor themselves before eating or leaving work. However, survey records from the early 1950s indicated that few workers performed self-monitoring.

Identification of asbestos and PCB hazards did not emerge until the 1970s or later. During the fourth quarter of 1973, some of the first air samples for asbestos were taken and sent to Oak Ridge National Laboratory (ORNL) for analysis; however, no formal asbestos program existed until 1987. During this period, OSHA adopted 14 carcinogen standards. In 1975, preparations were under way for a two-year program to provide formal respiratory training on a sitewide basis. There was less concern over worker exposure to PCBs through absorption, and many workers wore PCB-contaminated clothing. Some workers considered PCBs to be an effective remedy for dry skin.

The health physics staff provided exposure monitoring services, recommended training and protective measures for supervisors, maintained exposure and radiation measurement records, administered a bioassay program, investigated air samples and personnel exposures that were outside of specifications, studied Plant hazards and needed controls, and performed Plant environmental monitoring. However, the size of the Health Physics Section (i.e., two to six people during the first 37 years of operation) limited the amount and effectiveness of surveillance and monitoring of hazardous conditions and activities for the approximately 1,200 to 2,500 people in numerous and diverse work environments. While line supervision had always been responsible for implementing recommended controls and protective measures, supervisory oversight and worker implementation of PPE and related measures were inconsistent. Non-compliant PPE use by workers can in part be attributed to the pressures to maintain normal process operations, a lack of knowledge and understanding of the risks involved and why the protection was needed, and the physical discomfort and vision impairment associated with wearing PPE, such as respirators, in hot, dirty environments.

Safety Equipment